I – Problem Statement Title (EQ 159)

Determine the Vulnerability of California's Bridges to Tsunami

II – Research Problem Statement

Question: How Vulnerable are Bridges Designed Using Caltrans Current Criteria to Tsunami Waves?

There are about 200 bridges along California's Coast that could be hit by a large tsunami wave. These bridges will eventually be replaced and (as California's coastal development continues) additional new bridges will be built. Do we need to make any changes to our Seismic Design Criteria (SDC) to address potential bridge vulnerabilities to large tsunami?

III – Objective

STAP Roadmap Outcome: 7. Improved Understanding of Seismic Hazards

Determine the vulnerabilities of bridges designed to our current criteria from tsunami. Determine how large a wave is required to cause a bridge collapse. Determine if our current policy of displacement-based design makes bridges safer from tsunami. Determine if our current box girder with barrier rail cross section needs to be modified to lower its resistance to dynamic fluid pressure moving around the structure. Determine if Caltrans bridges are capable of being submerged during a tsunami. Develop bridge criteria for tsunami.

IV – Background

Bridges are often damaged and destroyed during tsunami. A tsunami caused by the 1946 Aleutian earthquake struck the Island of Hawaii, destroying the railway with its bridges that carried sugar cane to Hilo. The 1964 Great Alaska earthquake not only destroyed bridges on Kodiak Island, but the waves continued south, destroying bridges in Washington, Oregon, and California. In 1994, a locally-generated tsunami in the Kuril Islands in Japan traveled upriver, destroying several bridges. The 2004 Sumatra earthquake and tsunami destroyed bridges on both sides of the Indian Ocean.

The Network for Earthquake Engineering Simulation (NEES) operates a tsunami wave basin generator that has tested a variety of structural components, but nothing similar to a bridge designed to our current seismic criteria. There are other wave generators, managed by the US government and military, in Maryland and Virginia.

Currently there are no bridge criteria for tsunami. The State of Hawaii has retrofitted a few bridges to prevent the superstructure from being washed away by a tsunami. California's Land Commission has developed tsunami criteria for ports and terminals that have been adopted into the California Building Code (CBC). The US Corps of Engineers has written a "Tsunami Engineering" handbook for designing structures to survive tsunami waves.

V – Statement of Urgency, Benefits, and Expected Return on Investment

A devastating tsunami like the one that struck the Indian Ocean Region (and killed a quarter of a million people) can also strike California. This research will help ensure that our roads and bridges can remain in service following a devastating tsunami. Reducing highway damage will allow emergency supplies to reach the devastated area and facilitate the long-term recovery of the region. This can be accomplished by determining what vulnerabilities exist for bridges designed to Caltrans Seismic Design Criteria (SDC).

VI – Related Research

"Use of Experimental Facilities in NEES Collaboratory Research," W Holmes, B Kutter, S Mahin, T Prudhomme, A, CUREE Org

VII – Deployment Potential

As a result of this research, Caltrans will be able to determine the vulnerability of its bridge along California's coast. Existing bridges can be retrofit or replaced with more tsunami-resistant structures. Engineers will have tools for making bridges safer for tsunami. Caltrans management will be able to make intelligent decisions about funding retrofits or replacements based on an understanding of the vulnerability of bridges in the highway system.